

CLAIMS

What is claimed is:

1. A method of induction heat treatment, comprising the steps of:

selecting an article for heat treatment comprising a metal wall having an upper hub portion, a lower hub portion, a bell-shaped portion that is located between the upper hub portion and the lower hub portion and a longitudinal axis extending through each of the upper hub portion, lower hub portion and bell-shaped portion, the bell-shaped portion having a bell-shaped outer surface, an inner surface and a plurality of windows extending from the outer surface to the inner surface;

selecting an induction coil comprising a hollow metal channel having a first termination portion, a second termination portion and a semi-rectangular inductor portion that is operably connected to the first termination portion and the second termination portion; wherein the inductor portion is adapted to receive the article and apply a plurality of magnetic fields to a heat treatment portion thereof;

placing the article within the inductor portion of the induction coil;

rotating the article within the induction coil at a selected speed;

energizing the induction coil to apply the magnetic fields and produce induction currents within the heat treatment portion of the article for a time sufficient to induce heating of the heat treatment portion to a heat treatment temperature (T_H) to at least a selected case depth; and

cooling the heat treatment portion of the article to a temperature (T_C) to the selected case depth.

2. The method of claim 1, wherein the article comprises nodular cast iron.
3. The method of claim 2, wherein T_H is greater than the austenite transition temperature.
4. The method of claim 3, wherein said step of cooling comprises quenching the article.
5. The method of claim 4, wherein said step of cooling comprises quenching until T_C is lower than the martensite transformation temperature.
6. The method of claim 1, wherein the article comprises a differential housing.
7. The method of claim 6, wherein the differential housing comprises induction hardenable grade cast iron.
8. The method of claim 7, wherein T_H is in the range of 1600 - 1900 °F.
9. The method of claim 7, wherein said step of cooling comprises quenching the article.

10. The method of claim 1, wherein the semi-rectangular inductor portion comprises:

a semi-rectangular lower coil portion comprising a first L-shaped section having a first termination end, that is connected to the first termination portion, and a first lateral end, and an opposed second L-shaped section having a second termination end, that is connected to the second termination portion, and a second lateral end;

a semi-rectangular upper coil portion, having a first lateral end and a second lateral end, that is located above and is proportionately smaller than the lower coil portion;

a first lateral portion that connects the first lateral end of the upper coil portion to the first lateral end of the lower coil portion; and

a second lateral portion that connects the second lateral end of the upper coil portion to the second lateral end of the lower coil portion, wherein during the step of energizing, the first lateral portion produces a first lateral magnetic field that is adapted to act on the heat treatment portion of the differential housing and the second lateral coil portion produces a second lateral magnetic field that is adapted to act on the heat treatment portion of the differential housing.

11. The method of claim 10, wherein the step of energizing comprises the application of an electric current to the induction coil having a frequency in the range of about 10 kHz.

12. A method of induction heat treatment of a heat treatment portion of a differential housing, comprising the steps of:

selecting an induction coil comprising a hollow metal channel having a first termination portion, a second termination portion and a semi-rectangular inductor portion that is operably connected to the first termination portion and the second termination portion; wherein the inductor portion is adapted to receive the article and apply a plurality of magnetic fields to a heat treatment portion thereof;

placing the article within the inductor portion of the induction coil;

rotating the article within the induction coil at a selected speed;

energizing the induction coil to apply the magnetic fields and produce induction currents within the heat treatment portion of the article for a time sufficient to induce heating of the heat treatment portion to a heat treatment temperature (T_H) to at least a selected case depth; and

cooling the heat treatment portion of the article to a temperature (T_C) to the selected case depth.

13. The method of claim 12, wherein the differential housing comprises nodular cast iron.

14. The method of claim 13, wherein T_H is greater than the austenite transition temperature.

15. The method of claim 14, wherein T_H is in the range of 1600 - 1900 °F.

16. The method of claim 14, wherein said step of cooling comprises quenching the differential housing.

17. The method of claim 16, wherein said step of cooling comprises quenching until T_C is lower than the martensite transformation temperature.

18. A housing, comprising:

a metal wall having an upper hub portion, a lower hub portion, a bell-shaped portion that is located between the upper hub portion and the lower hub portion, a longitudinal axis extending through each of the upper hub portion and a circumferential hardened case, the bell-shaped portion having a bell-shaped outer surface, an inner surface and a plurality of windows extending from the outer surface to the inner surface, the circumferential hardened case extending inwardly from the bell-shaped outer surface in a heat treatment portion which is located between the window and the upper hub, wherein the hardened case is formed by an induction heat treatment.

19. The article of claim 18, wherein the induction heat treatment comprises the steps of:

selecting an induction coil comprising a hollow metal channel having a first termination portion, a second termination portion and a semi-rectangular inductor portion that is operably connected to the first termination portion and the second termination portion; wherein the inductor portion is adapted to receive the article and apply a plurality of magnetic fields to a heat treatment portion thereof;

placing the article within the inductor portion of the induction coil;

rotating the article within the induction coil at a selected speed;

energizing the induction coil to apply the magnetic fields and produce induction currents within the heat treatment portion of the article for a time sufficient to induce heating of the heat treatment portion to a heat treatment temperature (T_H) to at least a selected case depth; and

cooling the heat treatment portion of the article to a temperature (T_C) to the selected case depth.

20. The article of claim 19, wherein the induction hardened case comprises a martensitic microstructure.

21. The article of claim 20, wherein the martensitic microstructure is a tempered martensitic microstructure.

22. The article of claim 21, wherein the tempered martensitic microstructure is formed by the induction heat treatment.

23. The article of claim 22, wherein the tempered martensitic microstructure has a hardness of about R_C 40 - 50.

24. The article of claim 23, wherein the tempered martensitic microstructure extends from the outer surface to the inner surface in the heat treatment portion.

25. An induction coil, comprising:
a hollow metal channel having a first termination portion, a second termination portion and a semi-rectangular inductor portion that is operably connected to the first termination portion and the second termination portion.

26. The induction coil of claim 25, wherein the semi-rectangular inductor portion comprises:

a semi-rectangular lower coil portion comprising a first L-shaped section having a first termination end, that is connected to the first termination portion, and a first lateral end, and an opposed second L-shaped section having a second termination end, that is connected to the second termination portion, and a second lateral end;

a semi-rectangular upper coil portion, having a first lateral end and a second lateral end, that is located above and is proportionately smaller than the lower coil portion;

a first lateral portion that connects the first lateral end of the upper coil portion to the first lateral end of the lower coil portion; and

a second lateral portion that connects the second lateral end of the upper coil portion to the second lateral end of the lower coil portion.

27. The induction coil of claim 26, wherein the hollow metal channel is rectangular having an outer width of about 10 mm and an outer height of about 10 mm and a thickness of about 1.1 mm.